REPORT

Electricity Energy Efficiency Market Potential Study

Submitted to NorthWestern Energy

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1 Executive Summary

1.1 Overview

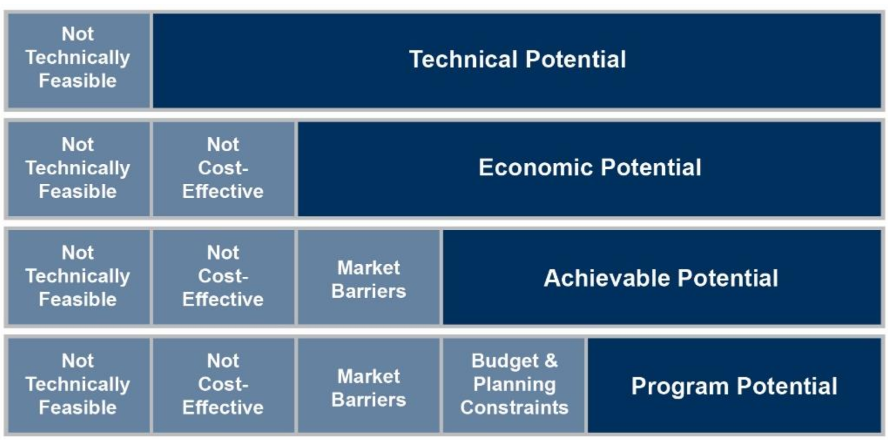
This report identifies and characterizes the remaining, achievable, cost-effective electricity energy efficiency potential in NorthWestern Energy's (NorthWestern's) Montana electricity supply territory for the period 2015-2034.

This study builds upon previous assessments completed in 2009 while incorporating enhancements with respect to both the scope of analysis and the methodology used for modeling potential energy savings.

1.2 Scope of Analysis

The energy efficiency potential in the NorthWestern's territory can be characterized by levels of opportunity. The ceiling or theoretical maximum is based on commercialized and emerging technologies and behavior measures, whereas the realistic savings that may be achieved through demand-side management (DSM) programs reflects real world market constraints such as utility budgets, customer perspectives, and energy efficiency policy. This analysis defines these levels of energy efficiency potential according to the Environmental Protection Agency's (EPA) National Action Plan for Energy Efficiency (NAPEE) as illustrated in Figure 1-1.[1]

Figure 1-1: Energy Efficiency Potential



EPA – National Guide for Resource Planning

- Technical Potential is the theoretical maximum amount of energy and capacity that could be displaced by efficiency, regardless of cost and other barriers that may prevent the

[1] The EPA National Action Plan for Energy Efficiency: http://www.epa.gov/cleanenergy/documents/suca/napee_report.pdf

installation or adoption of an energy-efficiency measure. Technical potential is only constrained by factors such as technical feasibility and applicability of measures.

- Economic Potential is the amount of energy and capacity that could be reduced by efficiency measures that pass a cost-effectiveness test. This analysis used the Total Resource Cost (TRC) Test, which estimates the measure costs to both the utility and customer.
- Achievable Potential is the energy savings that can feasibly be achieved through program and policy interventions.
- Program Potential reflects the realistic quantity of energy savings the utility can realize through DSM programs during the horizon defined in the study. Potential delivered by programs is often less than achievable potential, due to real-world constraints, such as program utility program budgets, effectiveness of outreach, and market delays.

This study explores technical, economic, and achievable energy efficiency potential (program potential is not included in this assessment). The quantification of these three levels of energy efficiency potential is an iterative process reflecting assumptions on cost effectiveness that drill down the opportunity from the theoretical maximum to realistic program savings. The California Standard Practice Manual (SPM) provides the methodology for estimating cost effectiveness of energy efficiency measures, bundles, programs or portfolios based on a series of tests representing the perspectives of the utility, customers, and societal stakeholders.[2] In this potential study, individual measures were screened for cost-effectiveness using the total resource cost (TRC) from the Standard Practice Manual. Potential savings described throughout this report represent the sum of annual incremental savings for the time period of 2015 – 2034.

1.3 Results

Summary tables and figures in this section reflect the results of cost-effectiveness screening using the Total Resource Cost (TRC) test. A TRC ratio of 1.0 was used to screen measures for cost-effectiveness. Avoided energy costs provided by NorthWestern were used to calculate the total cost-effectiveness benefits based on measure energy savings while cost-effectiveness costs were based on measure incremental costs.

The electricity energy efficiency potential identified in this study is shown in Figure 1-2 and summarized in Table 1-1 and Table 1-2.

[2] California Standard Practice Manual: http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

Figure 1-2: Projected 2015-2034 Potential by Sector

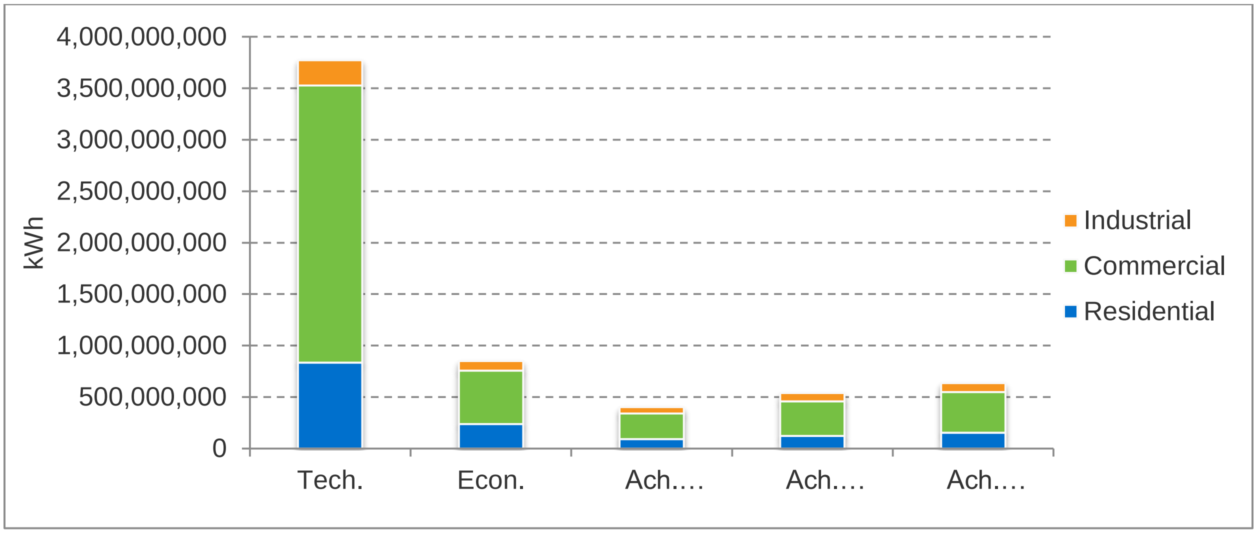


Table 1-1: Forecast Annual Sales and Sum of Annual Incremental Tech/Econ Potential 2015 – 2034 (kWh)

	Baseline Sales - 2034	Technical		Economic	
		Savings Potential	% of Sales	Savings Potential	% of Sales
Res	2,961,147,696	837,057,881	28.3%	237,606,028	8.0%
Com	3,425,163,076	2,691,881,087	78.6%	520,764,468	15.2%
Ind	1,006,514,739	244,099,558	24.3%	93,676,741	9.3%
Total	7,392,825,511	3,773,093,276	51.0%	852,047,238	11.5%

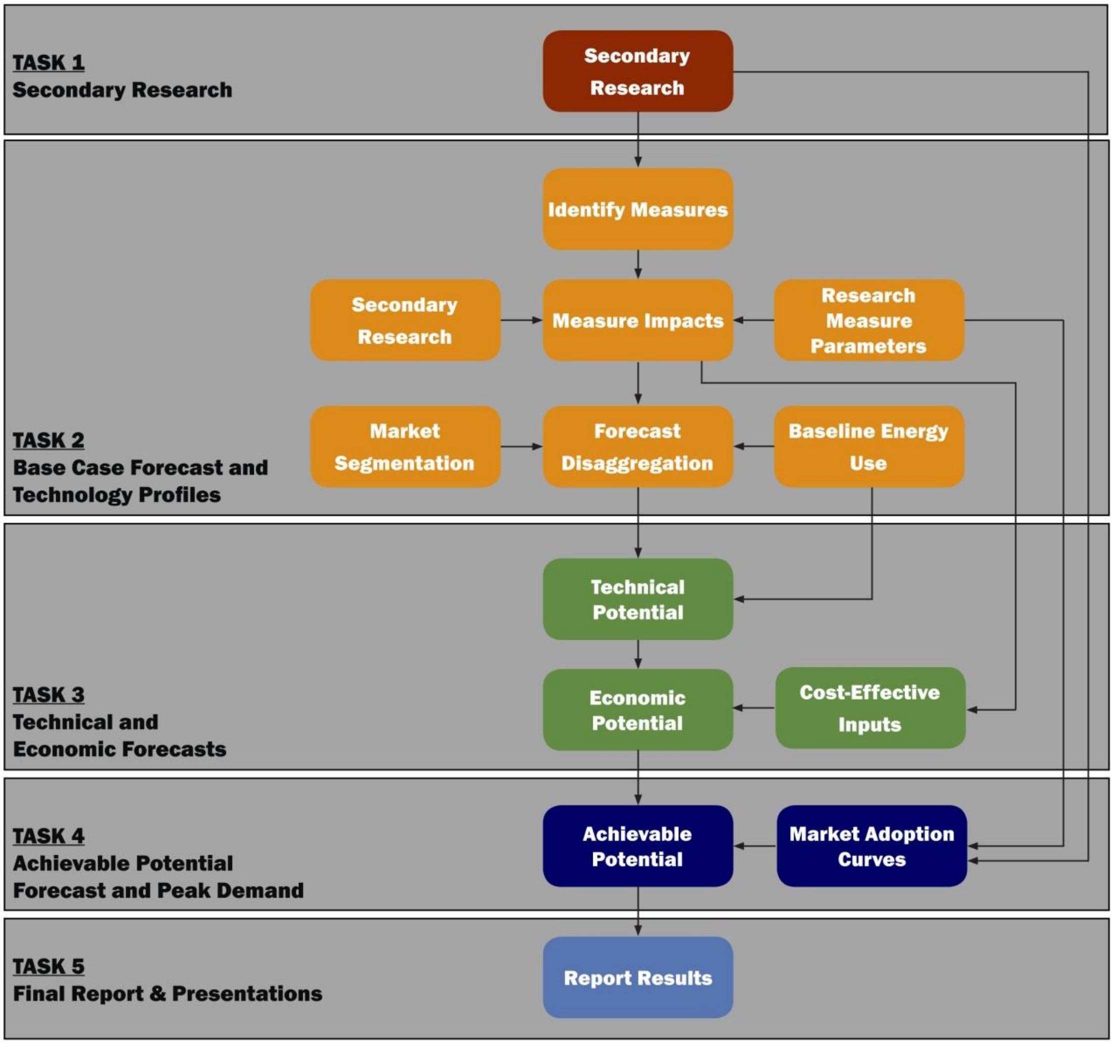
Table 1-2: Forecast Annual Sales and Sum of Annual Incremental Achievable Potential 2015 – 2034 (kWh)

	Baseline Sales - 2034	Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
		Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales
Res	2,961,147,696	91,679,918	3.1%	123,083,672	4.2%	155,249,699	5.2%
Com	3,425,163,076	248,294,911	7.2%	337,428,646	9.9%	395,937,175	11.6%
Ind	1,006,514,739	63,349,533	6.3%	79,625,689	7.9%	85,722,730	8.5%
Total	7,392,825,511	403,324,362	5.5%	540,138,008	7.3%	636,909,604	8.6%

2 Method

Energy efficiency potential studies involve a number of analytical steps to produce estimates of each type of energy efficiency potential: technical, economic, and achievable. This study utilized Nexant's Microsoft Excel-based modeling tool, TEA-POT (Technical/Economic/Achievable Potential). This modeling tool is built on a platform that provides the ability to calculate multiple scenarios and recalculate potential savings based on variable inputs such as sales/load forecasts, electricity prices, discount rates, and actual program savings. This model provides NorthWestern with the transparency into the assumptions and calculations for estimating market potential. TEA-POT has been consistently refined over the past several years with industry best practices, with the most recent upgrade occurring in 2016.The methodology for the energy efficiency potential assessment is based generally on a hybrid "top-down/bottom-up" approach. As illustrated in Figure 2-1, the assessment begins with the current load forecast, then decomposes it into its constituent customer-class and end-use components, and examines the effect of the range of energy efficiency measures and practices on each end use, taking into account fuel shares, current market saturations, technical feasibility, and costs. These unique impacts are then aggregated to produce estimates of potential at the end-use, customer-class, and system levels.

Figure 2-1: Approach to Energy Efficiency Potential Modeling



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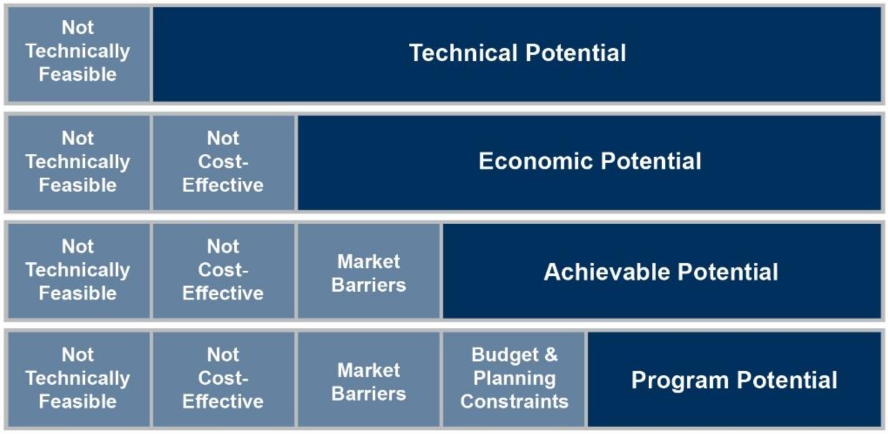
[3] The EPA National Action Plan for Energy Efficiency: http://www.epa.gov/cleanenergy/documents/suca/napee_report.pdf

Figure 2-2: Energy Efficiency Potential



EPA – National Guide for Resource Planning

- Technical Potential is the theoretical maximum amount of energy and capacity that could be displaced by efficiency, regardless of cost and other barriers that may prevent the installation or adoption of an energy-efficiency measure. Technical potential is only constrained by factors such as technical feasibility and applicability of measures.
- Economic Potential is the amount of energy and capacity that could be reduced by efficiency measures that pass a cost-effectiveness test. The Total Resource Cost (TRC) Test estimates the measure costs to both the utility and customer.
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[4] California Standard Practice Manual: http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

Naturally occurring conservation[5] is captured by this analysis in the load forecast. Effects of energy codes and equipment standards are taken into account by explicitly incorporating changes to codes and standards and marginal efficiency shares in the development of the base-case forecasts. In this study, it is assumed that new buildings will comply with Montana's building codes – the 2012 International Energy Conservation Code (IECC). Additionally the model accounts for future federal code changes that will impact efficiencies, and therefore overall potential energy savings, of specific measures and end uses such as motors and lighting. For example, the model accounts for the anticipated "backstop" provision outlined in the Energy Information and Security Act (EISA) lighting efficiency standards by adjusting the potential savings available to be aligned with federal efficiency standards of 45 lumens per watt beginning in 2020. Potential savings described throughout this report represent the sum of annual incremental savings for the time period of 2015 – 2034.

2.1 End-Use Market Characterization

A critical first step in estimating energy efficiency potential is establishing a realistic energy use baseline and end-use saturation characterization from which a 20-year "business as usual" forecast can be developed. For this study, Nexant conducted an end-use saturation study via onsite data collection to both residential and commercial properties. Nexant conducted this work in fall of 2015 and summarized results in the Energy End Use and Load Profile Study provided to NorthWestern in August 2016. The end-use saturation study collected, analyzed, and summarized market data (fuel shares, energy system saturations, and structural characteristics), end-uses (unit energy consumption (UEC), energy use intensities (EUI), and load shapes), technology shares, and measure characteristics (technologies, costs, life, and savings). These data fed directly into calibration of the energy efficiency potential model and provided valuable measure-level information on current saturation and applicability. The approach described below outlines this process and is followed by a discussion of the approach to defining the existing energy savings baseline for energy-efficiency measures.

The Energy End Use and Load Profile Study served as Nexant's most significant primary data source to inform the market characterization. In areas where data gaps were identified, Nexant relied on additional primary data collected through NorthWestern's E+ Energy Audit for the Home and E+ Energy Appraisal for Businesses programs. Secondary data usage was limited to the Energy Information Agency's Residential and Commercial Buildings Energy Consumption Surveys to inform UEC and EUI values.

2.2 Load Disaggregation and Forecast

After the collection, analysis, and summary of the end-use saturation data, the next step is to disaggregate the most recent year of complete sales (2014) into a baseline year. In this study,

[5] Naturally occurring conservation refers to gains in energy efficiency that occur as a result of normal market forces such as technological change, energy prices, market transformation efforts, and improved energy codes and standards.

Nexant disaggregated end-use loads and technologies and applied them across the study horizon by:

- Determining energy consumption per customer class and segment in baseline year.
- Disaggregating customer class loads into end-use loads, such as water heating.
- Segmenting end-uses loads into technologies, such as water heaters.
- Analyzing and calibrating data to 2014.
- Forecasting the 20-year end-use energy consumption through 2034.

2.2.1 Determine Energy Consumption per Customer Class and Segment in Baseline Year

The first step in the forecast disaggregation is to analyze energy loads for the residential, commercial, and industrial customer classes. Separate models were developed for the residential, commercial, and industrial sector. Segmentation was developed per market segment as follows:

- **Residential:** Base and Low-Income customers with single-family home, multi-family home, and manufactured home.
- **Commercial:** Education, Grocery, Large and Small Health, Large and Small Office, Lodging, Restaurant, Retail, Warehouse, Miscellaneous.
- **Industrial:** (see section 3.4 for full list of industrial segments)

2.2.2 End-Use Load Classification

The next step in the forecast disaggregation analysis is to establish the end-use loads within the residential, commercial, and industrial market segments. A sample of the types of end-use loads to be analyzed is found in Table 2-1.

Table 2-1: End-Use Loads by Sector

Residential	Commercial	Industrial
Central AC	Lighting	Process Heating
Central Heat	Exterior Lighting	Process Cooling
Cooking Oven	Heating	Compressed Air
Cooking Range	Cooling	Motors Pumps
Dryer	Water Heat	Motors Fans Blowers
Freezer	Cooking	Motors Other
HVAC Aux	Plug Load	Process Specific
Heat Pump	Heat Pump	Lighting
Lighting	Ventilation	HVAC
Other	Refrigeration	Other

Residential	Commercial	Industrial
Plug Load	Miscellaneous	-
Refrigerator	-	-
Room AC	-	-
Room Heat	-	-
Water Heat	-	-

2.3 Technologies Classification and Measure List Research

Once the baseline forecast is disaggregated, the next step to assessing market potential is to accurately detail the universe of efficiency measures and their end use – applied savings, costs, and lifetimes. Measures that are currently implemented in NorthWestern's electricity programs received careful consideration since these measures have a historical record and vendors have proven processes for implementation. Additionally Nexant compiled all measures available from technical reference manuals (TRMs), such as those used for the Regional Technical Forum, State of Pennsylvania or Minnesota, as well as other measures Nexant has characterized in similar studies. From these regionally relevant databases, Nexant selected measures that are commonly available, based on well-understood technology, and applicable to the buildings and end uses in NorthWestern's service territory. Consideration was also given to measures that show promise for future viability but have not yet gained a foothold in the market.

Energy efficiency potential in the stock of premises can be captured over time through three principal processes:

- **Turnover:** As equipment replacements are made normally in the market when a piece of equipment is at the end of its effective useful life (also referred to as "replace-on-burnout")
- **Retrofit:** At any time in the life of the equipment or building (referred to as "early-retirement").
- **New:** When a new home or building is constructed.

Upon finalization of the energy efficiency measure list, data on energy savings, costs, lifetime, and applicability is collected to determine potential measure impacts. This work is performed through a four-step process.

Step 1: Define market classes for application of measures

In line with the disaggregated load forecast, Nexant defined the applicability of the appropriate fuel type, sectors, market segments, vintages, and end-uses to each of the measures. These classes are defined as follows:

- **Customer Sectors:** Residential, commercial and industrial.
- **Market Segments:**
  - *Residential:* Base and Low-Income customers with single-family home, multi-family home, and manufactured home.
  - *Commercial:* Education, Grocery, Large and Small Health, Large and Small Office, Lodging, Restaurant, Retail, Warehouse, Miscellaneous
  - *Industrial* (see section 3.4 for full list of industrial segments)
- **Measure Type:** Equipment, Non-equipment [6]
- **Vintages:**
  - Equipment – Turnover, Retrofit, New
  - Non-equipment – Existing, New

Table 2-2 presents the quantity of unique measures and measure permutations included in the potential analysis. The quantity of unique measures represents the number of individual measures analyzed in the study, whereas the quantity of measure permutations represents the number of measures applied to the model for each vintage and segment.

Table 2-2: Measures Included in Potential Modeling

Sector	Unique Measures	Measure Permutations
Residential	114	1,728
Commercial	219	6,794
Industrial	89	3,960
Total	422	12,482

Step 2: Screen sectors, segments, and end-uses for eligibility

Nexant screened market segments and end-uses for applicability of specific energy efficient strategies. For example, certain commercial end-uses, such as cooking loads, may not be appropriate for segments such as offices and warehouses and were analyzed only in limited market sectors.

Step 3: Develop base case impacts and costs

For each of the energy efficiency measures on the final list, base case equipment and practices were determined. A description of all base case equipment and practices was documented,

[6] Equipment measures are units that actually consume energy, such as a furnace. Non-equipment measures do not consume energy, such as windows or insulation.

along with a description of why that particular base case was the best representation. All base case assumptions and data, such as state of Montana state building codes (the 2012 International Energy Conservation Code (IECC)) and federal standards, were included. Base case assumptions included projected future shifts in the base, such as upcoming Federal Standards[7].

Step 4: Develop energy efficiency measure impacts and costs

A description of all energy efficiency (or "change case") measure equipment and practices were also developed. All measure energy savings assumptions and calculation parameters, such as equivalent full load hours (EFLH), were provided and documented for transparency. For each measure, energy savings were estimated as a percentage of base equipment and/or end-use consumption.

In addition to energy savings, incremental measure costs, pertinent to NorthWestern Energy's Montana service territory, were collected from internet retailer research and appropriate TRM references. Research was also performed to determine the measure life for each energy efficiency measure based primarily on TRM documentation.

2.4 Estimate Energy Savings Potential and Determine Market Potential

Drawing on the previous data compilation, organization, and market analysis tasks, the estimation of market potential is conceptually a straightforward exercise.

2.4.1 Develop Baseline Forecast

The baseline forecast is created by combining all of the inputs compiled in prior tasks to obtain average consumption estimates by customer segment, construction vintage and end use, and summing these up to the sector level. The disaggregated forecast data provides the foundation. For example, in the residential sector, the general equation for the DSM baseline forecast is:

Equation 2-1

$$Forecast_{BL} = \sum_{i,j,t} HH_{i,t} \times EUS_{i,j,t} \times UEC_{i,j,t}$$

Where:

$HH_{i,t}$ = the number of households of type *i* in year *t*

[7] http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=4244256deb6e3f16076e5cb34c6b93d9&rgn=div8&view=text&node=10:3.0.1.4.18.3.9.2&idno=10

$EUS_{i,j,t}$ = the saturation of end use type *j* in household type *i* in year *t*

$UEC_{i,j,t}$ = the unit energy consumption of end use *j* in household type *i* in year *t*

2.4.2 Estimate Technical Potential

The measure-level inputs were used to estimate technical potential over the planning horizon. This is accomplished by creating an alternate forecast where consumption is reduced by the installation of all technically feasible measures.

2.4.2.1 Equipment Measures

For technical potential, which represents substitution of all technically feasible technical measures at the end use level (and following the residential example above), the general equation is:

Equation 2-2

$$Forecast_{TP} = \sum_{i,j,t} HH_{i,t} \times EUS_{i,j,t} \times UEC_{i,j',t}$$

Where:

$HH_{i,t}$ = the number of households of type i in year t

$EUS_{i,j,t}$ = the saturation of end use type *j* in household type *i* in year *t*

$UEC_{i,j',t}$ = the unit energy consumption of end use *j'* (the most efficient end use technology configuration) in household type *i* in year *t*

The technical potential for equipment measures is simply the difference between Equation 2-1 and Equation 2-2.

2.4.2.2 Non-Equipment Measures

Estimating the potential for non-equipment (or "retrofit") measures required assessing the collective impacts of many measures with interactive effects. For each segment and end-use combination, the analysis objective sought to estimate cumulative effects of the group of eligible measures, incorporating those impacts into the end-use model as a percentage adjustment to baseline end-use consumption. In other words, the approach estimated the percentage reduction in end-use consumption that could be saved in a "typical" structure (e.g., office buildings, retail building) by installing all available measures. This approach began by characterizing individual measure savings in terms of their percentage of end-use consumption, rather than their absolute energy savings. The following basic relationship estimated savings for each individual, non-equipment measure:

Equation 2-3

$$SAVE_{ijm} = EUI_{ije} * PCTSAV_{ijem} * APP_{ijem}$$

Where:

$SAVE_{ijm}$ = annual energy savings for measure *m* for end use *j* in customer segment *i*.

EUI_{ije} = calibrated annual end-use energy consumption for the equipment *e* for end use *j* and customer segment *i*.

$PCTSAV_{ijem}$ = the percentage savings of measure *m* relative to base usage for the end-use configuration *ije*, taking into account interactions among measures.

APPijem = measure applicability, a fraction representing a combination of technical feasibility, existing measure saturation, and adjustments to account for competing measures.

A measure's savings can be appropriately viewed in terms of its savings as a percentage of baseline end-use consumption, given its overall applicability. For example, if wall insulation had overall applicability of only 50%, 10% savings in space cooling consumption would yield a final 5% savings for this end use. This value would represent the percentage of baseline consumption the measure would save in an average commercial building.

However, capturing all applicable measures required examining many instances where multiple measures affected a single end use. To avoid overestimating total savings, assessment of cumulative impacts accounted for interaction among various measures, a treatment known as "measure stacking." Stacking effects can be accounted for primarily by establishing a rolling, reduced baseline, applied sequentially to measures in the stack, as shown in the equations below, which apply measures 1, 2, and 3 to the same end use:

$$SAVE_{ij1} = EUI_{ije} * PCTSAV_{ije1} * APP_{ije1}$$

$$SAVE_{ij2} = (EUI_{ije} - SAVE_{ij1}) * PCTSAV_{ije2} * APP_{ije2}$$

$$SAVE_{ij3} = (EUI_{ije} - SAVE_{ij1} - SAVE_{ij2}) * PCTSAV_{ije3} * APP_{ije3}$$

Measures can be stacked using different criteria, such as total savings or cost-effectiveness. For this study, the total savings determined the stacking order for measures within each end use for the technical scenario. For economic and achievable scenarios, the stacking order is based on measure benefit-cost ratios for the cost-effectiveness test selected.

2.4.2.3 Interactive Effects

Further, the approach accounted for the following interactive effects:

- **Equipment and non-equipment measures:** Installing high-efficiency equipment, such as a central air conditioner, could reduce energy savings in absolute terms (kWh) associated with non-equipment measures, such as wall insulation. For example, installing a high-efficiency central air conditioner reducing space cooling consumption by

15% would reduce the baseline against which insulation would be applied, thus reducing savings associated with installing insulation.

- **Equipment measure interactions:** This interaction occurred when two or more measures “competed” for the same end use. For example, a 13 SEER central air conditioner could be replaced with a 15 SEER central air conditioner.

2.4.3 Estimate Economic Potential

The next step is to create an alternative forecast of “economic” DSM potential (i.e., considering the most efficient measures that pass economic screening tests), specifically the Total Resource Cost (TRC) was utilized to screen individual measures. Again following the residential example, the general equation is:

Equation 2-4

$$Forecast_{EP} = \sum_{i,j,t} HH_{i,t} \times EUS_{i,j,t} \times UEC_{i,j'',t}$$

Where:

$HH_{i,t}$ = the number of households of type *i* in year *t*

$EUS_{i,j,t}$ = the saturation of end use type *j* in household type *i* in year *t*

$UEC_{i,j'',t}$ = the unit energy consumption of end use *j"* (the most efficient end use technology configuration that is also economic) in household type *i* in year *t*

Similar to the calculation of technical potential, the economic potential for DSM is the difference between Equation 2-1 and Equation 2-4.

2.4.3.1 Calculate Cost Effectiveness

Nexant determined measure cost-effectiveness using accepted industry-standard TRC cost-effectiveness test, described below, to gauge the economic merits of the portfolio. This test compares the benefits of the energy efficiency measures to their costs using its own unique perspectives and definitions in terms of net present value of future cash flows.

- Total Resource Cost test (TRC). The benefits in this test are the lifetime avoided energy costs. The costs in this test are the incremental measure costs.

Equation 2-5:

$$\text{TRC Ratio} = \text{Avoided Energy Costs}/\text{Incremental Measure Costs}$$

Nexant utilized a cost-effectiveness hurdle of 1.0.

Nexant then produced estimates of levelized cost-of-conserved-energy (CCE) for each measure by integrating resource data (per-unit costs, savings, and measure life) with baseline building stock data (base-case fuel and end-use saturations, measure applicability factors, and current measure saturations) and baseline energy usage data. NorthWestern provided utility-specific data on avoided energy costs, distribution losses, discount rates, and inflation rates[8], which were incorporated to perform a full cost-benefit analysis for every rate class, sector, customer segment, vintage, end use, and measure combination. The avoided energy costs were derived from a combination of avoided capacity and energy cost values; this approach was consistent with the Qualifying Facilities docket number D2016.5.39 methodology. The 20 year levelized avoided energy cost used in this analysis was $0.041 per kilowatt-hour.

2.5 Estimate Achievable Potential

The assessment of realistically achievable energy efficiency potential requires estimating, among other parameters, the rate at which cost-effective measures can be adopted over time. Because program implementation scenarios have a direct influence over such market penetration rates, calculating achievable potential typically incorporates individually developed sets of market penetration curves corresponding to implementation scenarios. These scenarios may be correlated to differing levels of urgency in program implementation, tolerance for rate impacts, macroeconomic conditions, or other situations.

There are important components in the determination of achievable potential:

- **Customers' willingness to participate.** The likelihood that customers will participate in energy efficiency programs is a function of several factors, including incentive level, which is designed to offset the incremental cost a consumer would pay between a standard efficiency and high efficiency measure. Achievable potential was estimated for three different incentive-level scenarios (33%, 50%, and 75%) to examine the variance in expected savings.
- **Uncertainty.** Filing and planning requirements often necessitate a point-estimate of potential; however, this is not an accurate reflection of the reality of DSM programs. It is preferred to think of achievable potential as a range, or probability distribution, where the point-estimate is the most likely outcome. This distribution defines the lower and upper bounds of expected savings, as well as the most likely value.

2.5.1 Adoption Curves

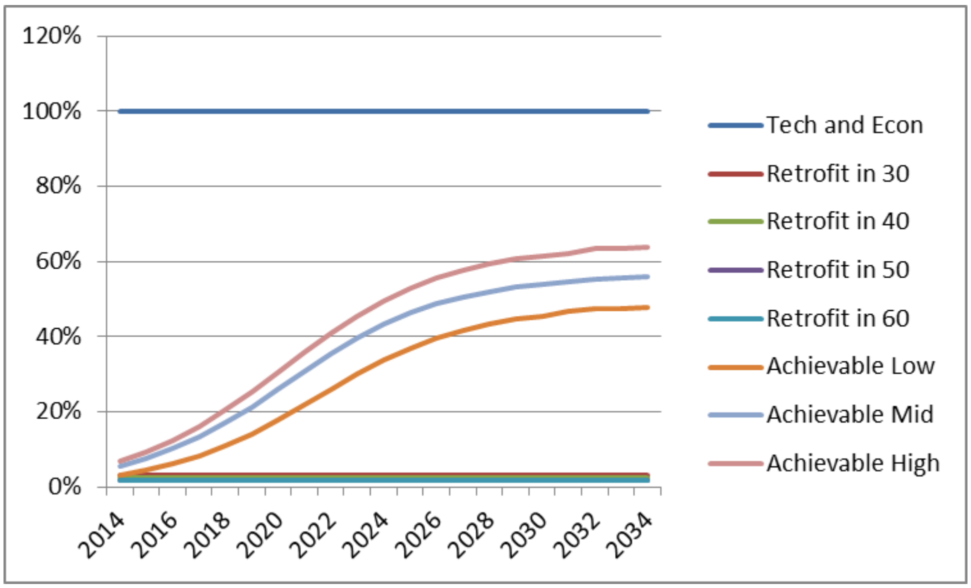
The last test step in determining realistic, achievable energy efficiency potential is to develop an adoption rate forecasting the expected share of eligible program participants within a year. Table 2-3 and Figure 2-3 summarize the modeling scenarios utilized and examples of the market adoption curves for equipment and non-equipment measures.

[8] Avoided energy levelized cost: $0.041/kWh; distribution loss: 8.51%; discount rate: 7.03%; inflation rate: 1.80%

Table 2-3: Potential Modeling Scenarios

	Incentive Rate	Adoption Rate
Technical	100%	Most aggressive
Economic	100%	Most aggressive
Achievable Low	33%	Low
Achievable Mid	50%	Moderate
Achievable High	75%	High

Figure 2-3: Example Market Adoption Curves



Market adoption curves are assigned to each measure permutation according to best estimates of how the market will adopt that measure over time. As shown in the figure above, market adoption can be as high as 100% (for equipment turnover measures in the technical and economic scenarios, for instance), and as low as 1% (for non-equipment measures in the achievable low scenario, for instance). While the achievable adoption curves shown above are intended to represent gradual maturation of programs followed by an eventual plateau as the market reaches saturation, the retrofit curves mimic the steady transformation of the market over a given period. Market adoption curves are assigned to measures according to their type, vintage, and scenario.

3 Market Characterization

This section provides a brief characterization of NorthWestern's Montana electricity market by sector, segment, and end use (the industrial sector is characterized only by segment). Baseline electricity usage characteristics are based on the results of the Energy End Use and Load Profile Study completed in August 2016 by Nexant on behalf of NorthWestern Energy. These data are based on NorthWestern electric sales for 2014; additional resolution on the methodology and findings of sales and load shapes by end use and segment can be found in that report. "Choice" electric customers i.e., customers who are permitted to procure energy from alternative sources or providers, are excluded from this study.

The tables in this section include electric energy consumption shares as a percentage of the overall electric usage, not to be confused with the end use saturation or percentage of NorthWestern Energy customers with a particular end use.

3.1 Electricity Market Overview

Table 3-1: Overall Electricity Consumption by Sector

Sector	2014 Baseline Sales (kWh)	Share (%)
Residential	2,356,041,721	40.3%
Commercial	2,692,525,699	46.1%
Industrial	791,222,707	13.5%
Total	5,839,790,127	100.0%

Figure 3-1: Overall Electricity Consumption by Sector

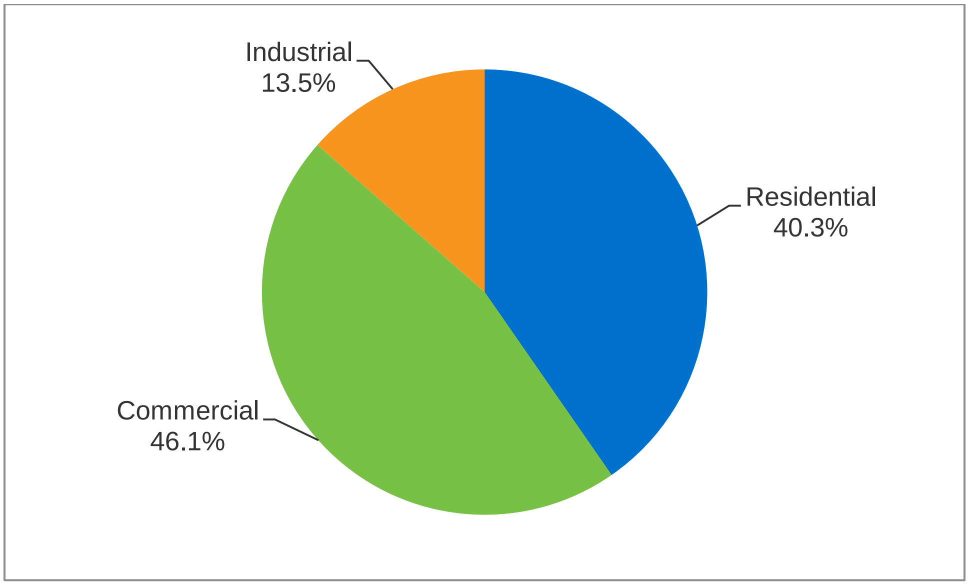
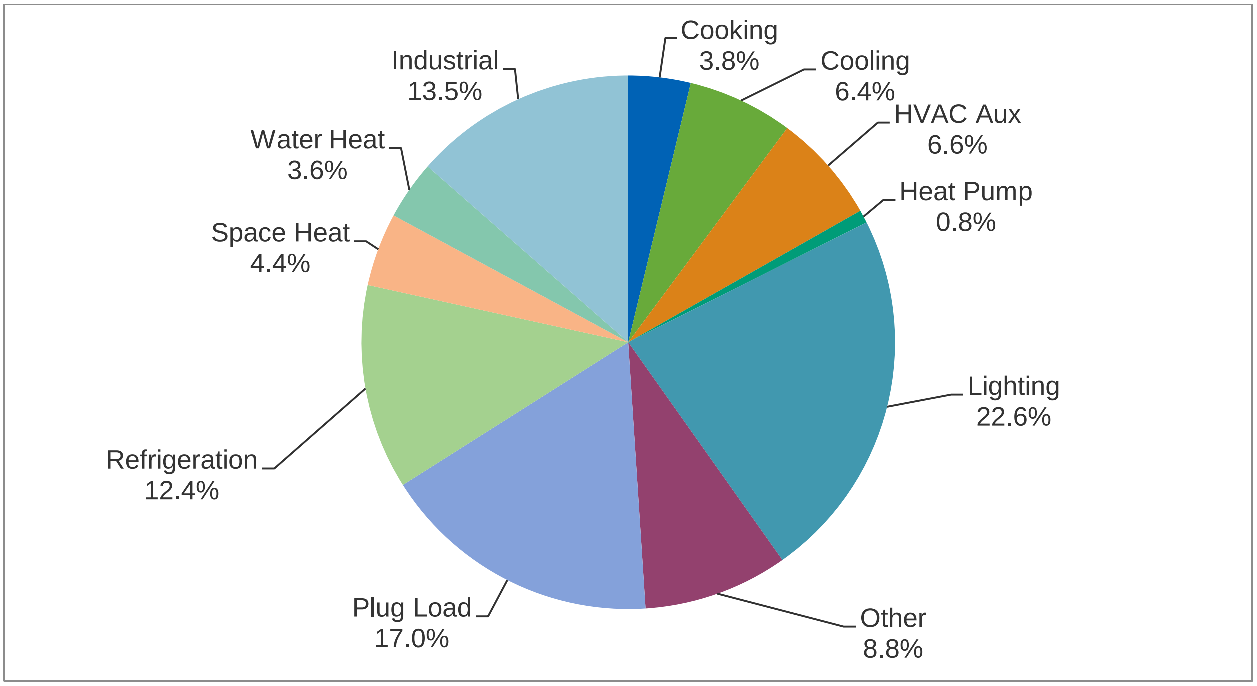


Table 3-2: Overall Electricity Consumption by End Use

	Baseline Sales (kWh)	Share (%)
Cooking	219,862,473	3.8%
Cooling	373,503,592	6.4%
HVAC Aux	387,567,029	6.6%
Heat Pump	45,969,253	0.8%
Lighting	1,320,527,174	22.6%
Other	512,065,814	8.8%
Plug Load	995,634,404	17.0%
Refrigeration	725,753,132	12.4%
Space Heat	259,508,833	4.4%
Water Heat	208,175,715	3.6%
Industrial	791,222,707	13.5%
Total	5,839,790,127	100.0%

Figure 3-2: Overall Electricity Consumption by End Use



3.2 Residential Sector Overview

Table 3-3: Residential Electricity Consumption by Segment

Home Type	Baseline Sales (kWh)	Share (%)
Single Family	1,785,297,036	75.8%
Multifamily	267,788,694	11.4%
Mfg Homes	210,796,283	8.9%
Single Family Low Income	70,528,955	3.0%
Multifamily Low Income	12,447,455	0.5%
Mfg Low Income	9,183,298	0.4%
Total	2,356,041,721	100.0%

Figure 3-3: Residential Electricity Consumption by Segment

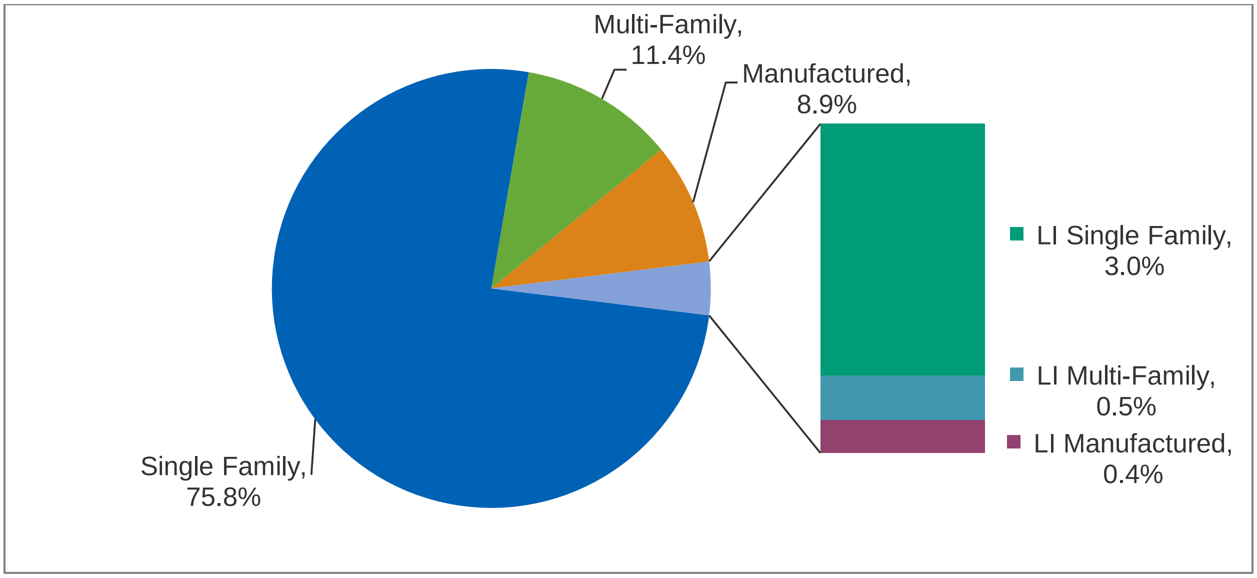
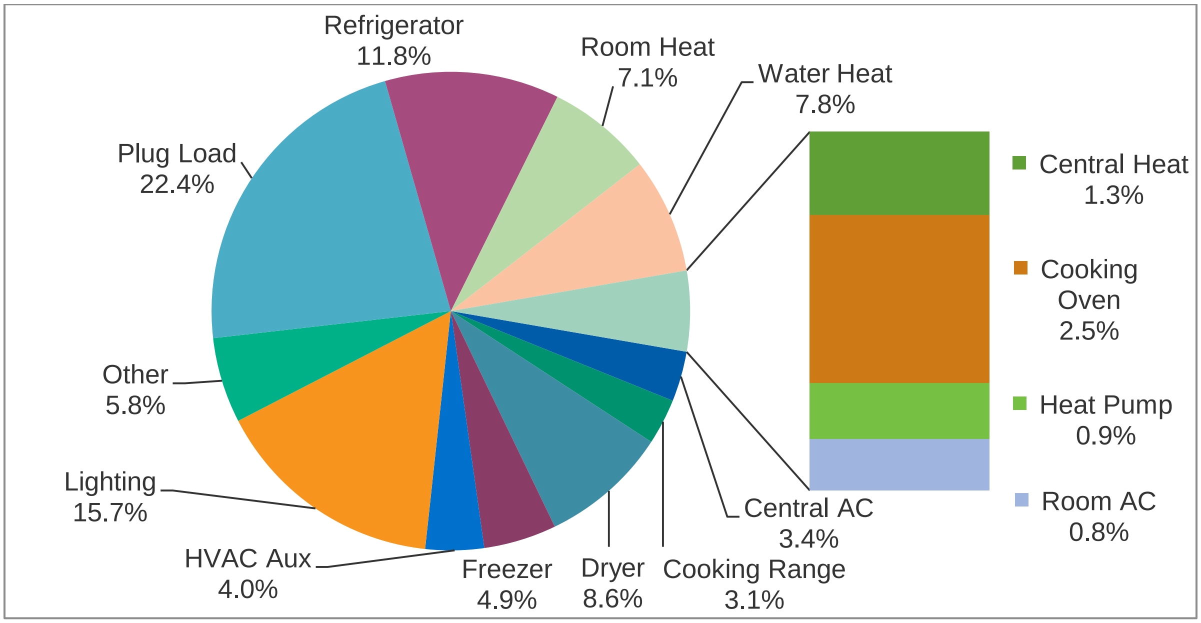


Table 3-4: Residential Electricity Consumption by End Use

	Baseline Sales (kWh)	Share (%)
Central AC	79,860,591	3.4%
Central Heat	29,772,149	1.3%
Cooking Oven	59,979,219	2.5%
Cooking Range	72,907,939	3.1%
Dryer	203,658,991	8.6%
Freezer	115,872,357	4.9%
HVAC Aux	93,074,014	4.0%
Heat Pump	20,033,053	0.9%
Lighting	369,934,881	15.7%
Other	136,142,594	5.8%
Plug Load	526,978,246	22.4%
Refrigerator	277,647,060	11.8%
Room AC	18,333,114	0.8%
Room Heat	168,232,758	7.1%
Water Heat	183,614,754	7.8%
Total	2,356,041,721	100.0%

Figure 3-4: Residential Electricity Consumption by End Use



3.3 Commercial Sector Overview

Table 3-5: Commercial Electricity Consumption by Segment

Segment	Baseline Sales (kWh)	Share (%)
Education	184,472,015	6.9%
Grocery	158,681,982	5.9%
Large Health	126,930,446	4.7%
Large Office	197,476,436	7.3%
Lodging	163,226,989	6.1%
Miscellaneous	523,115,720	19.4%
Restaurant	116,622,324	4.3%
Retail	454,670,465	16.9%
Small Health	126,922,900	4.7%
Small Office	439,819,293	16.3%
Warehouse	200,587,128	7.4%
Total	2,692,525,699	100.0%

Figure 3-5: Commercial Electricity Consumption by Segment

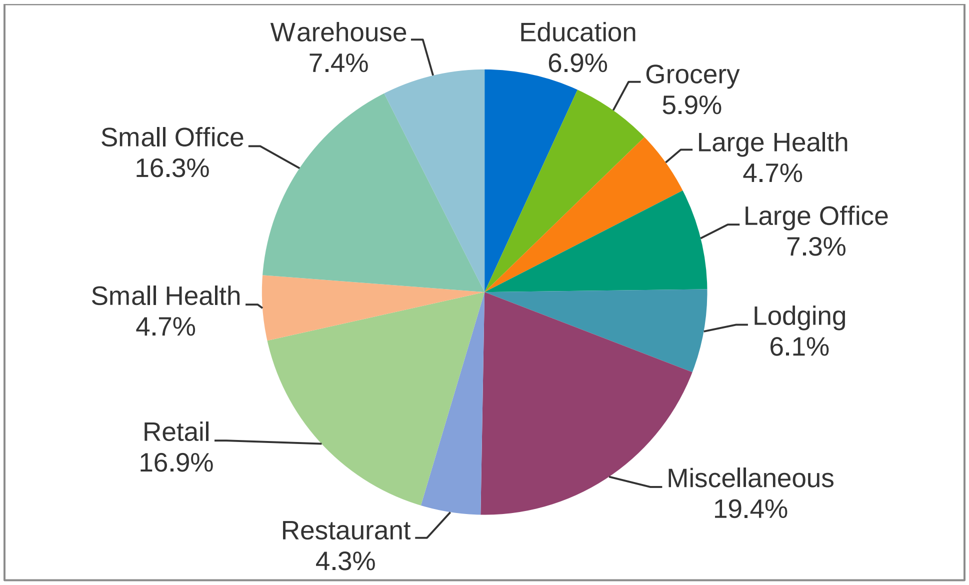
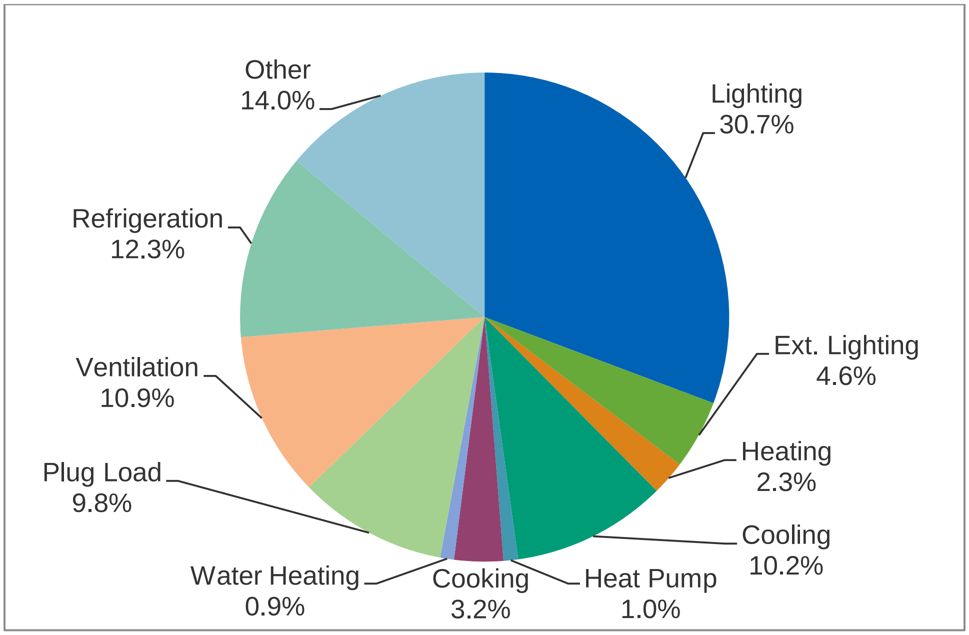


Table 3-6: Commercial Electricity Consumption by End Use

	Baseline Sales (kWh)	Share (%)
Cooking	86,975,315	3.2%
Cooling	275,309,887	10.2%
Exterior Lighting	123,064,260	4.6%
HVAC Aux	294,493,015	10.9%
Heat Pump	25,936,199	1.0%
Lighting	827,528,032	30.7%
Other	375,923,220	14.0%
Plug Load	264,997,168	9.8%
Refrigeration	332,233,715	12.3%
Space Heat	61,503,926	2.3%
Water Heat	24,560,961	0.9%
Total	2,692,525,699	100.0%

Figure 3-6: Commercial Electricity Consumption by End Use



3.4 Industrial Sector Overview

Table 3-7: Industrial Electricity Consumption by Segment

Segment	Baseline Sales	Share (%)
Agriculture	43,474,691	5.5%
Chemical Mfg	1,313,560	0.2%
Construction	94,758,022	12.0%
Electrical Equipment Mfg	19,967,980	2.5%
Fabricated Metal Products	8,119,513	1.0%
Food Mfg	93,490,344	11.8%
Furniture Manufacturing	7,845,136	1.0%
Industrial Machinery	47,548,874	6.0%
Irrigation	84,778,005	10.7%
Mining	203,987,526	25.8%
Miscellaneous	14,058,218	1.8%
Nonmetallic Mineral Products	3,921,454	0.5%
Petroleum Coal Products	33,067,538	4.2%
Plastic and Rubber Mfg	3,203,171	0.4%
Primary Metal Mfg	18,112,638	2.3%
Textile Manufacturing	16,554,487	2.1%

Segment	Baseline Sales	Share (%)
Transportation Equipment Mfg	3,574,647	0.5%
Water	59,607,885	7.5%
Wood Product Mfg	33,839,018	4.3%
Total	791,222,707	100.0%

4 Technical Potential

This section presents the results of the technical potential analysis. The methodology for the estimation of technical potential is described in detail in Section 2.

4.1 Summary of Results

Table 4-1 shows the 2034 annual baseline electricity sales and technical potential by sector for the period from 2015 - 2034. The results indicate that approximately 3.77 million MWh of technically feasible electricity energy efficiency potential are available by the end of the 20-year study period. Technical potential amounts to a 51.0% reduction in 2034 forecasted non-choice electricity sales.

Table 4-1: Forecast Annual Sales and Sum of Annual Incremental Technical Potential 2015 – 2034 (kWh)

	Baseline Sales 2034	Technical	
		Potential	% of Sales
Res	2,961,147,696	837,057,881	28.3%
Com	3,425,163,076	2,691,881,087	78.6%
Ind	1,006,514,739	244,099,558	24.3%
Total	7,392,825,511	3,773,093,276	51.0%

5 Economic & Achievable Potential

This section presents the results of the economic and achievable potential analysis using the Total Resource Cost (TRC) test for screening the cost-effectiveness of measures. As explained in Section 2.4.3, benefit-cost ratios are also employed to rank and apply measures in order of cost effectiveness.

5.1 Summary of Results

Table 5-1 and Table 5-2 below summarize the 2034 annual baseline electricity sales and annual incremental technical, economic, and achievable potential by sector from 2015 - 2034. The results indicate that approximately 0.85 million MWh of economic potential—equivalent to 11.5% of forecasted baseline sales—will be available during the 20-year study period. The achievable low, mid, and high scenarios show cost-effective savings potential as it varies according to incentive rate and the corresponding market adoption rates. When employing the TRC test where the incentive is considered a net zero cost/benefit, the portfolio-wide achievable mid potential is nearly 0.54 million MWh, or 7.3% of baseline sales.

Table 5-1: Forecast Annual Sales and Sum of Annual Incremental Tech/Econ Potential 2015 – 2034 (kWh)

	Baseline Sales - 2034	Technical		Economic	
		Savings Potential	% of Sales	Savings Potential	% of Sales
Res	2,961,147,696	837,057,881	28.3%	237,606,028	8.0%
Com	3,425,163,076	2,691,881,087	78.6%	520,764,468	15.2%
Ind	1,006,514,739	244,099,558	24.3%	93,676,741	9.3%
Total	7,392,825,511	3,773,093,276	51.0%	852,047,238	11.5%

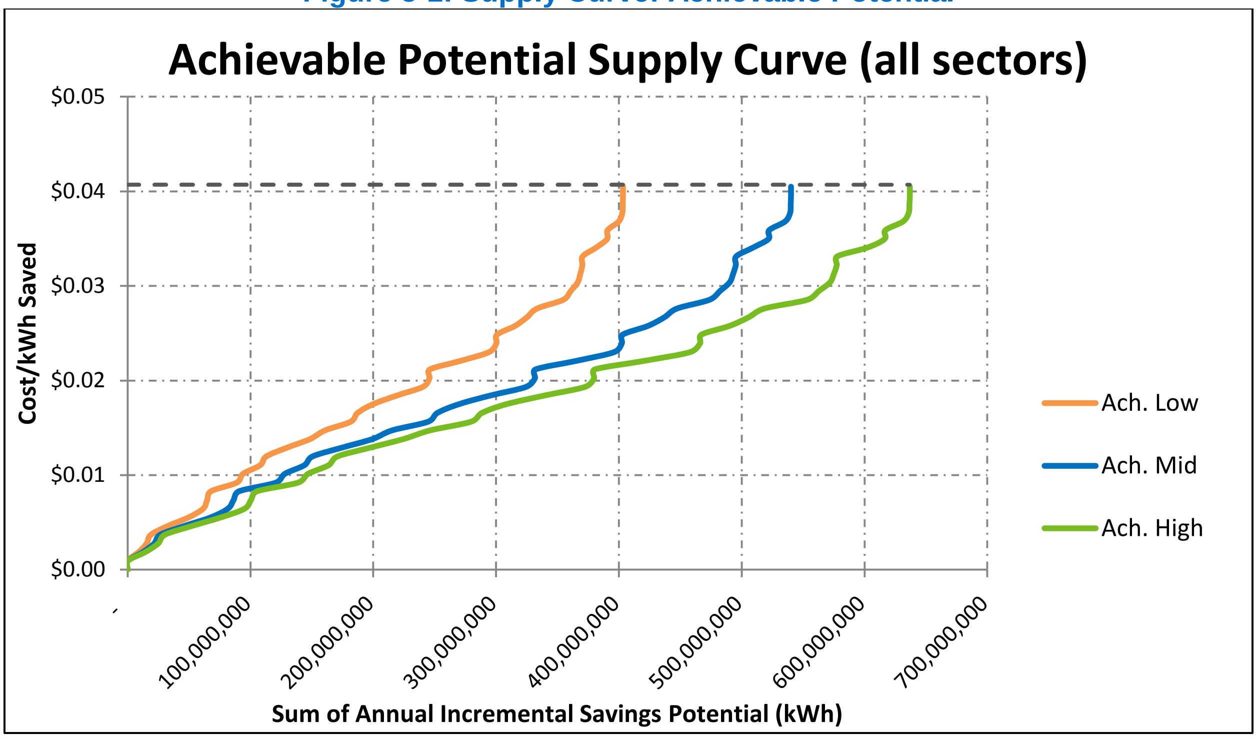
Table 5-2: Forecast Annual Sales and Sum of Annual Incremental Achievable Potential 2015 – 2034 (kWh)

	Baseline Sales - 2034	Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
		Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales
Res	2,961,147,696	91,679,918	3.1%	123,083,672	4.2%	155,249,699	5.2%
Com	3,425,163,076	248,294,911	7.2%	337,428,646	9.9%	395,937,175	11.6%
Ind	1,006,514,739	63,349,533	6.3%	79,625,689	7.9%	85,722,730	8.5%
Total	7,392,825,511	403,324,362	5.5%	540,138,008	7.3%	636,909,604	8.6%

As the tables above indicate, most of the cost-effective savings potential (approximately 61%) exists within the commercial sector. Economic potential within the residential and industrial sectors account for 28% and 11%, respectively, of total potential cost-effective electricity savings.

The supply curves shown in Figure 5-1 illustrate the relationship between achievable potential and the cost of avoided energy. Each supply curve represents achievable potential under the three incentive scenarios; 33% incentive, 50% incentive, and 75% incentive. Note that achievable potential under the base-case 2016 avoided costs maxes out at the dotted orange line intended to represent the levelized 20-year cost threshold.

Figure 5-1: Supply Curve: Achievable Potential



5.2 Sector-Level Findings

5.2.1 Residential Sector Potential

Residential customers in NorthWestern's Montana service territory are expected to account for roughly 40% of non-choice electricity sales in 2034. The single family, multifamily, and manufactured homes that comprise the residential sector present a variety of savings opportunities, including equipment efficiency upgrades (e.g., lighting), HVAC improvements (e.g., smart thermostats), and other non-equipment efficiency improvements such as low-flow showerheads that reduce electric water heating consumption.

As shown in Table 5-3, single family homes represent 76% of total economic potential in the residential sector. Multifamily, manufactured, and low income dwellings represent the remaining share of economic residential savings potential. A quick comparison with Figure 3-3 in the Market Characterization section reveals that economic savings potential by segment is generally aligned with each segment's proportion of baseline sales, with manufactured homes accounting for a slightly higher portion of savings potential than sales and multifamily homes accounting for a lower portion of savings potential than sales.

Table 5-3: Residential Sum of Annual Incremental Economic Potential by Segment 2015 – 2034 (kWh)

Segment	Economic	Share (%)
Single Family	180,021,106	75.8%
Multifamily	16,230,579	6.8%
Mfg Homes	29,722,595	12.5%
Single Family Low Income	9,155,479	3.9%
Multifamily Low Income	859,545	0.4%
Mfg Low Income	1,616,723	0.7%
Total	237,606,028	100.0%

Figure 5-2: Residential Sum of Annual Incremental Economic Potential by Segment 2015 – 2034

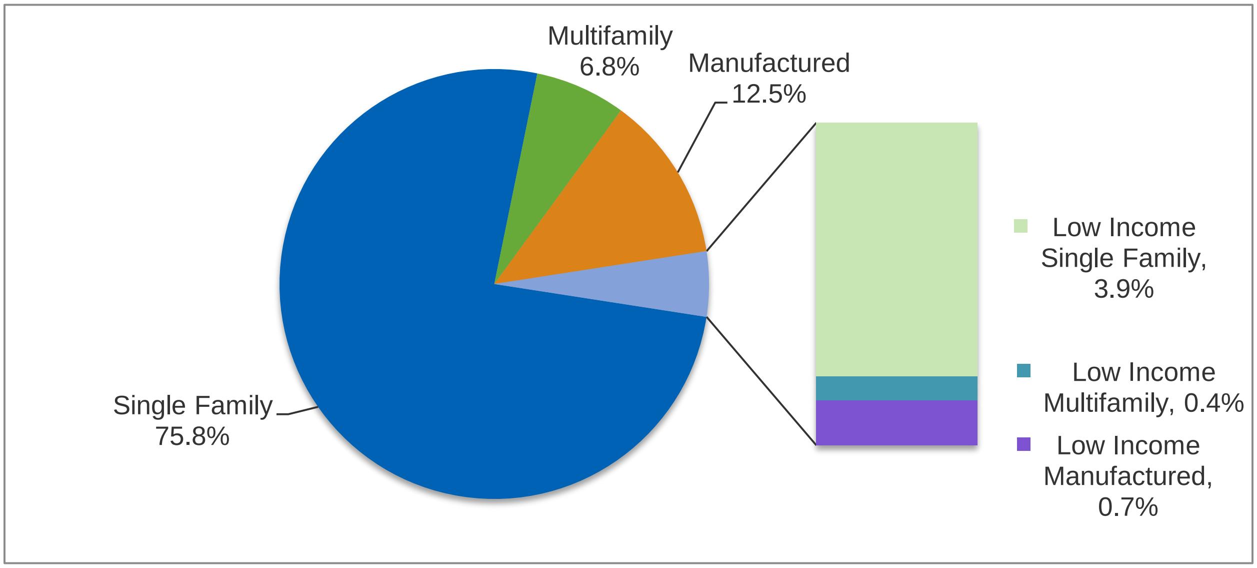


Table 5-4 shows residential economic potential by end use. Lighting and HVAC Auxiliary end uses represent approximately 69% of economic potential. This potential is followed by the Clothes end use, (dominated by savings from ENERGY STAR clothes washers and ENERGY STAR dryers), and the Plug Load end use (dominated by savings from ENERGY STAR computers). Many end uses including Central and Room AC, Cooking, Refrigerator, Room Heat, and Heat Pump failed to capture any economic potential largely due to low avoided energy costs which ultimately caused the measures within these end uses to fail cost effectiveness.

Table 5-4: Residential Sum of Annual Incremental Economic Potential by End Use 2015 – 2034 (kWh)

	Economic	Share (%)
Central AC	-	0.0%
Central Heat	5,529,595	2.3%
Cooking	-	0.0%
Clothes	34,049,185	14.3%
Refrigerator	-	0.0%
HVAC Aux	76,177,460	32.1%
Interior Lighting	64,931,434	27.3%
Plug Load	29,380,908	12.4%
Exterior Lighting	22,318,069	9.4%
Room AC	-	0.0%
Room Heat	-	0.0%
Water Heat	4,787,058	2.0%
Heat Pump	-	0.0%
Other	432,317	0.2%
Total	237,606,028	100.0%

Figure 5-3: Residential Sum of Annual Incremental Economic Potential by End Use 2015 – 2034

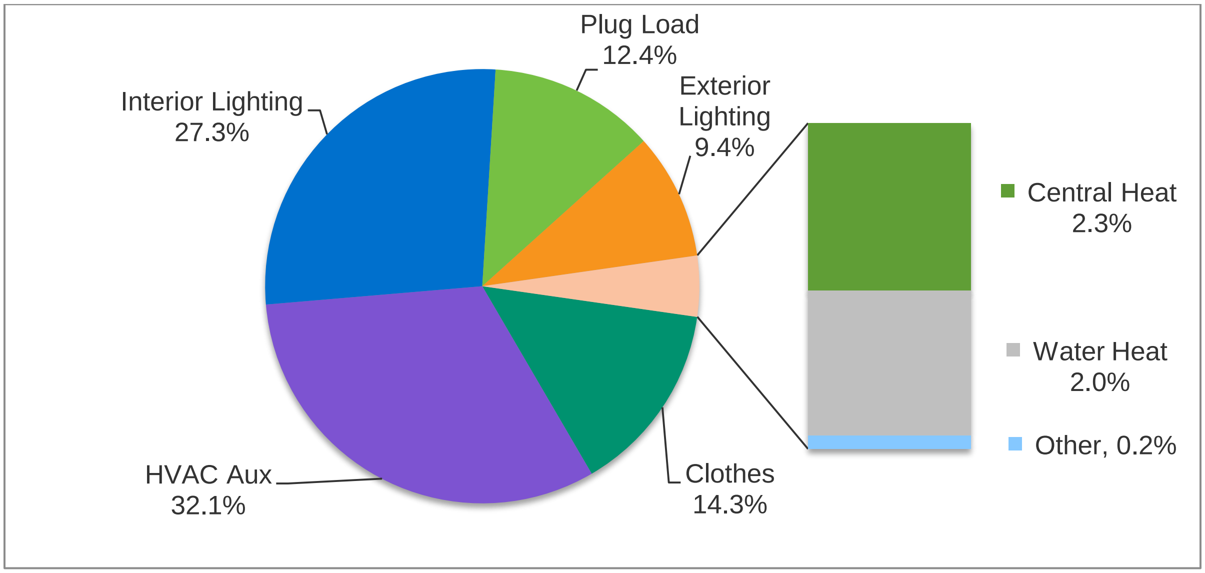


Table 5-5 shows estimated residential energy potential available in each scenario. The economic and achievable potential for residential lighting is significantly lower as a relative opportunity from prior assessments due to the expected impacts of the implementation of the Energy and Independence Security Act lighting "backstop" that effectively sets the baseline standard equivalent to a compact fluorescent lamp (45 lumens per watt) after 2020. The primary cause of fluctuation in the achievable results screened using the TRC test is due to variation in program adoption rates according to the incentive being offered.

Table 5-5: Sum of Residential Annual Baseline Sales and Annual Incremental Potential Details 2015 – 2034 (kWh)

	Baseline Sales - 2034	Economic		Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
		Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales
Central AC	103,657,363	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Central Heat	37,094,414	5,529,595	14.9%	2,684,435	7.2%	3,802,323	10.3%	4,265,760	11.5%
Cooking	182,373,255	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Clothes	261,227,669	34,049,185	13.0%	16,731,942	6.4%	23,874,632	9.1%	26,591,215	10.2%
Refrigerator	511,015,575	-	0.0%	-	0.0%	-	0.0%	-	0.0%
HVAC Aux	124,573,102	76,177,460	61.2%	15,083,432	12.1%	18,844,695	15.1%	35,812,070	28.7%

	Baseline Sales - 2034	Economic		Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
Interior Lighting	408,996,173	64,931,434	15.9%	37,824,568	9.2%	49,760,828	12.2%	54,040,957	13.2%
Plug Load	748,401,564	29,380,908	3.9%	14,397,695	1.9%	20,567,517	2.7%	22,917,829	3.1%
Exterior Lighting	52,421,566	22,318,069	42.6%	4,216,847	8.0%	5,269,601	10.1%	10,024,772	19.1%
Room AC	24,439,241	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Room Heat	12,297,902	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Water Heat	252,542,254	4,787,058	1.9%	529,164	0.2%	661,453	0.3%	1,259,888	0.5%
Heat Pump	25,252,590	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Other	216,855,030	432,317	0.2%	211,836	0.1%	302,622	0.1%	337,208	0.2%
Total	2,961,147,696	237,606,028	8.0%	91,679,918	3.1%	123,083,672	4.2%	155,249,699	5.2%

5.2.2 Commercial Sector Potential

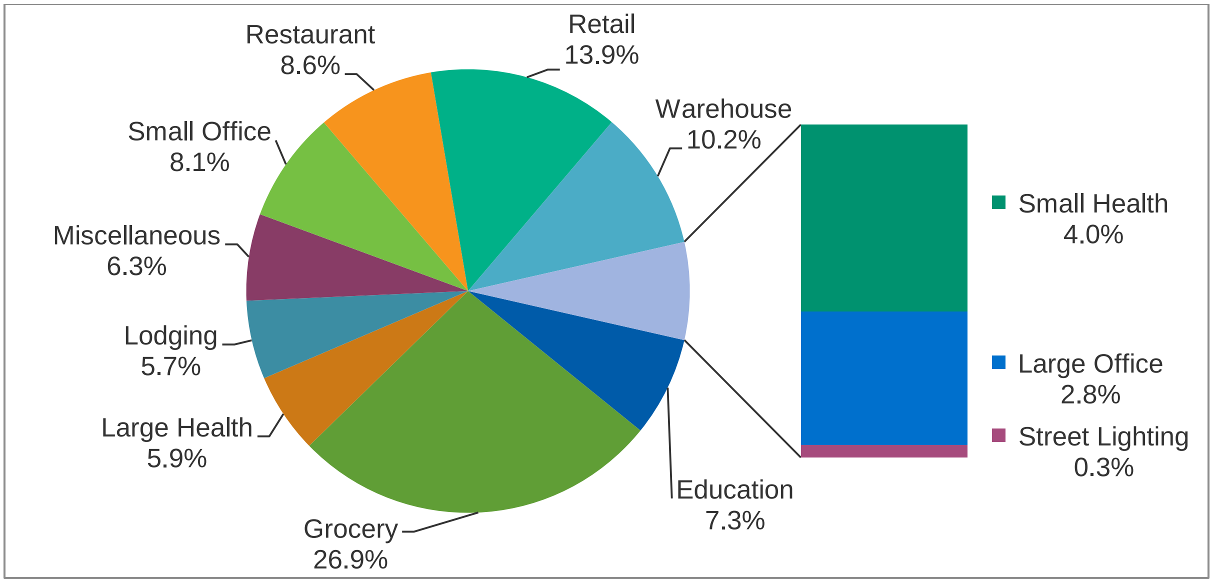
Economic electricity efficiency potential in the commercial sector is expected to be approximately 0.52 million MWh over the 20-year study period, equivalent to 15.2% of forecast commercial electricity sales in 2034.

As shown in Table 5-6 and Figure 5-4, grocery facilities represent the largest component (26.9%) of commercial potential followed by retail buildings (13.9%) and warehouse (10.2%) as the next highest ranked segments.

Table 5-6: Commercial Sum of Annual Incremental Economic Potential by Segment 2015 – 2034 (kWh)

	Economic Potential	Share (%)
Education	37,886,862	7.3%
Grocery	139,982,942	26.9%
Large Health	30,522,265	5.9%
Small Health	20,799,546	4.0%
Lodging	29,856,021	5.7%
Miscellaneous	32,930,797	6.3%
Large Office	14,813,651	2.8%
Small Office	42,249,584	8.1%
Restaurant	44,694,002	8.6%
Retail	72,403,845	13.9%
Warehouse	53,233,242	10.2%
Street Lighting	1,391,713	0.3%
Total	520,764,468	100.0%

Figure 5-4: Commercial Sum of Annual Incremental Economic Potential by Segment 2015 – 2034



By end use, lighting (linear and non-linear) represents the majority of economic potential (45.2%). Refrigeration demonstrates the next highest economic potential at 31.6%.

Table 5-7: Commercial Sum of Annual Incremental Economic Potential by End Use 2015 – 2034 (kWh)

	Economic Potential	Share (%)
Cooking	15,307,868	2.9%
Cooling DX	241,242	0.0%
Exterior Lighting	1,391,713	0.3%
HVAC Aux	60,551,637	11.6%
Lighting	85,184,650	16.4%
Linear Lighting	148,255,655	28.5%
Plug Load	24,262,315	4.7%
Refrigeration	164,800,332	31.6%
Space Heat	690,307	0.1%
Water Heat	1,790,117	0.3%
Cooling Chillers	1,970,493	0.4%
Heat Pump	5,691,068	1.1%
Miscellaneous	10,627,072	2.0%
Total	520,764,468	100.0%

Figure 5-5: Commercial Economic Potential by End Use 2015 – 2034

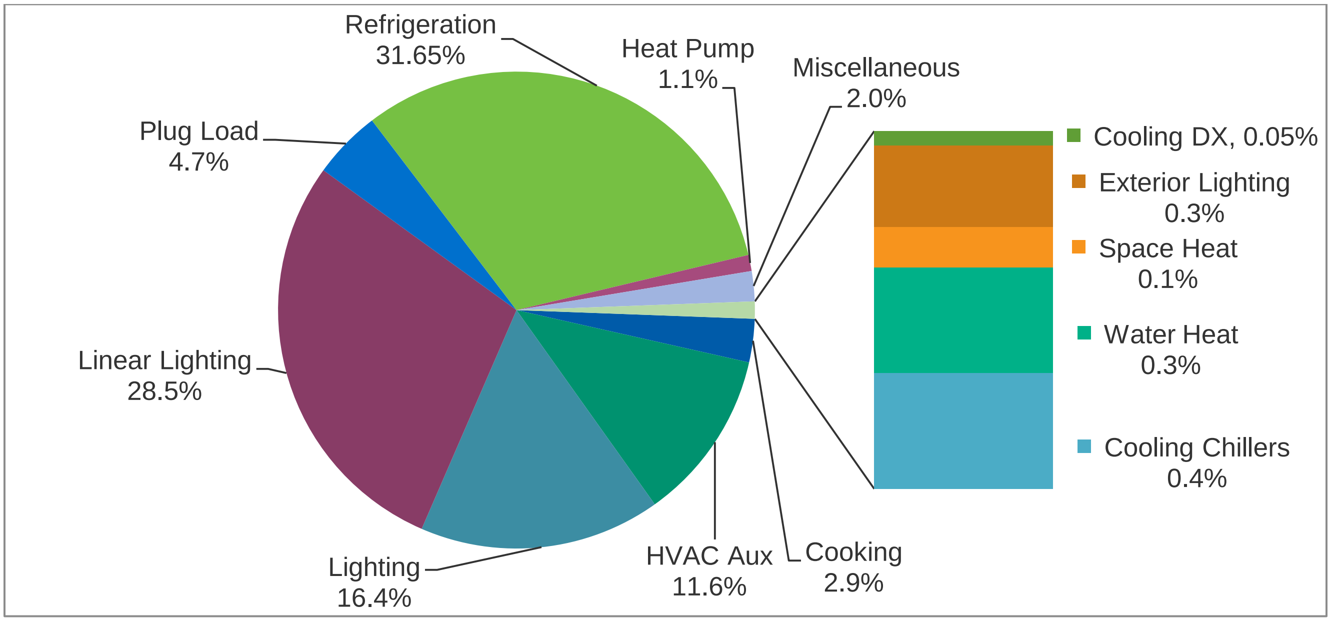


Table 5-8 below shows commercial potential available in each of the economic scenarios.

Table 5-8: Sum of Commercial Annual Baseline Sales and Annual Incremental Potential Details 2015 – 2034 (kWh)

	Baseline Sales - 2034	Economic		Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
		Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales
Cooking	109,786,931	15,307,868	14.0%	7,500,855	6.8%	10,715,507	9.8%	11,940,137	10.9%
Cooling DX	277,898,606	241,242	0.1%	118,209	0.0%	168,870	0.1%	188,169	0.1%
Exterior Lighting	154,099,220	1,391,713	0.9%	681,939	0.4%	974,199	0.6%	1,085,536	0.7%
HVAC Aux	357,362,754	60,551,637	16.9%	29,881,206	8.4%	39,825,433	11.1%	46,773,876	13.1%
Lighting	275,442,176	85,184,650	31.0%	42,500,157	15.4%	60,233,155	21.9%	66,951,688	24.3%
Linear Lighting	703,685,126	148,255,655	21.1%	72,352,328	10.3%	101,545,129	14.4%	114,892,242	16.3%
Plug Load	414,907,245	24,262,315	5.8%	11,634,366	2.8%	16,211,524	3.9%	18,596,560	4.5%
Refrigeration	437,857,576	164,800,332	37.7%	72,602,045	16.6%	92,831,488	21.2%	118,797,939	27.1%
Space Heat	65,691,567	690,307	1.1%	338,980	0.5%	483,828	0.7%	538,940	0.8%
Water Heat	31,969,847	1,790,117	5.6%	786,162	2.5%	1,025,059	3.2%	1,292,186	4.0%
Cooling Chillers	27,053,824	1,970,493	7.3%	828,685	3.1%	1,035,612	3.8%	1,380,274	5.1%
Heat Pump	35,530,332	5,691,068	16.0%	2,788,623	7.9%	3,983,748	11.2%	4,439,033	12.5%
Miscellaneous	533,877,872	10,627,072	2.0%	6,281,354	1.2%	8,395,094	1.6%	9,060,594	1.7%
Total	3,425,163,076	520,764,468	15.2%	248,294,911	7.2%	337,428,646	9.9%	395,937,175	11.6%

5.2.3 Industrial

NorthWestern's industrial segment includes manufacturing facilities and other accounts that supply mining, irrigation, and agriculture operations, along with others. As explained in Section 3, "choice" electric customers are excluded from the potential study, which effectively removes the majority of industrial electricity sales from the pool of available savings potential. Over half of the economic savings potential in the industrial sector (51.4%) exists within the Lighting use.

Table 5-9: Industrial Sum of Annual Incremental Economic Potential by End Use 2015 – 2034 (kWh)

End Use	Economic Potential	Share (%)
Process Heating	-	0.0%
Process Cooling	2,322,729	2.5%
Compressed Air	734,551	0.8%
Motors Pumps	1,022,461	1.1%
Motors Fans Blowers	-	0.0%
Motors Other	16,029,218	17.1%
Process Specific	986,983	1.1%
Lighting	48,143,883	51.4%
HVAC	22,172,170	23.7%
Other	2,264,747	2.4%
Total	93,676,741	100%

Figure 5-6: Industrial Economic Potential by End Use

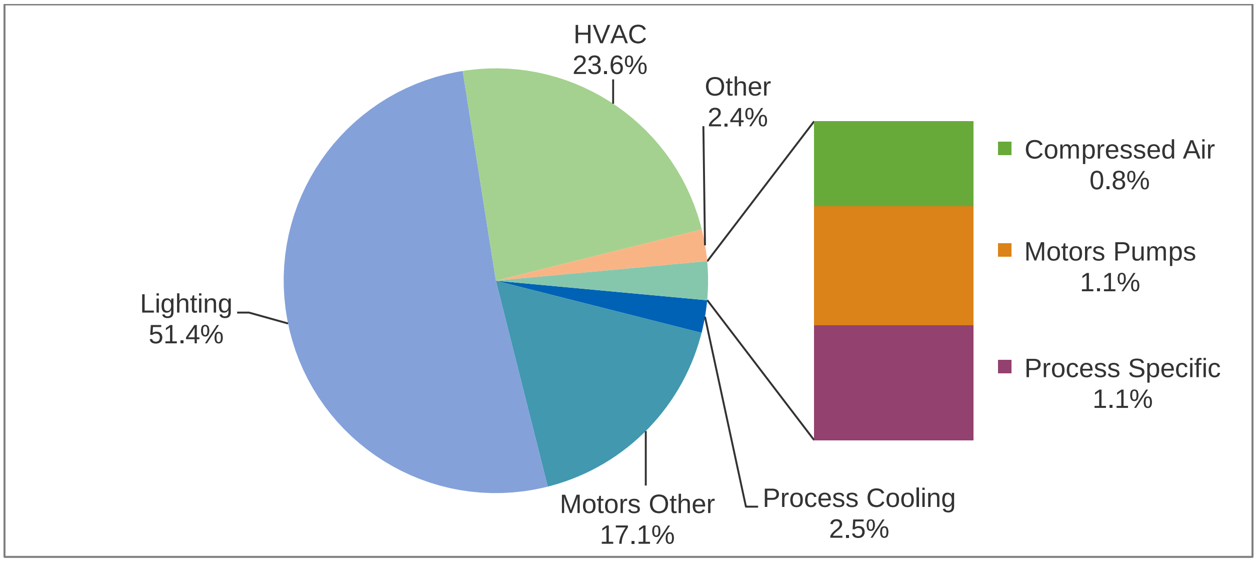


Table 5-10: Sum of Industrial Annual Baseline Sales and Annual Incremental Potential Details 2015 – 2034 (kWh)

	Baseline Sales - 2034	Economic		Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
		Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales
Process Heating	207,115,893	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Process Cooling	23,543,636	2,322,729	9.9%	1,172,030	5.0%	1,641,366	7.0%	1,850,060	7.9%
Compressed Air	2,475,366	734,551	29.7%	361,784	14.6%	508,342	20.5%	572,191	23.1%
Motors Pumps	260,399,597	1,022,461	0.4%	429,458	0.2%	536,817	0.2%	715,743	0.3%
Motors Fans Blowers	133,428,260	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Motors Other	41,774,352	16,029,218	38.4%	10,643,226	25.5%	14,768,410	35.4%	15,783,569	37.8%
Process Specific	82,062,923	986,983	1.2%	483,707	0.6%	690,960	0.8%	769,906	0.9%
Lighting	90,076,387	48,143,883	53.4%	35,613,089	39.5%	40,880,876	45.4%	43,035,740	47.8%
HVAC	122,584,428	22,172,170	18.1%	13,529,445	11.0%	19,007,661	15.5%	21,224,171	17.3%
Other	43,053,898	2,264,747	5.3%	1,116,795	2.6%	1,591,258	3.7%	1,771,351	4.1%
Total	1,006,514,739	93,676,741	9.3%	63,349,533	6.3%	79,625,689	7.9%	85,722,730	8.5%

5.3 Final Observations

This energy efficiency potential study was designed as an update to the 2009 potential study conducted on behalf of NorthWestern and is intended to assess the remaining cost-effective electric energy efficiency potential in the territory. NorthWestern's electric energy efficiency programs could save residents and business owners a substantial amount of electricity by 2034. Nexant estimates that the attainable achievable potential electricity savings at a 50% incentive rate amounts to 540,138 MWh (a 7.3% reduction in the projected annual forecasted sales in 2034).

The electric energy efficiency potential estimates and the TRC savings provided in this report are based on the latest load forecasts and avoided cost forecasts provided by NorthWestern. Over time, additional technologies are likely to become available in the market that may serve to increase the potential for energy and demand savings and warrant additional attention. Finally, actual energy and demand savings will depend upon the level and degree of NorthWestern customer participation in the energy efficiency programs offered.

Appendix A Cost-Effective Measures

The following measures are deemed cost effective for the potential modeling purposes. Cost effectiveness screening was assessed by a total resource cost (TRC) benefit-cost ratio of 1.0. Please see section 2.4.3.1 for additional detail on cost effectiveness screening.

#	Sector	End Use	Measure
		Residential	
6	Residential	Clothes	Clothesline
7	Residential	Clothes	ENERGY STAR® Clothes Dryer
11	Residential	Clothes	ENERGY STAR Clothes Washer
76	Residential	Plug Load	ENERGY STAR Dishwasher (Electric Water Heating)
79	Residential	Water Heat	Bathroom Faucet Aerators
80	Residential	Water Heat	Kitchen Faucet Aerators
81	Residential	Water Heat	Low-Flow Handheld Showerhead (1.60 gpm)
82	Residential	Water Heat	Low-Flow Handheld Showerhead (1.75 gpm)
83	Residential	Water Heat	Low-Flow Standard Showerhead (1.60 gpm)
84	Residential	Water Heat	Low-Flow Standard Showerhead (1.75 gpm)
97	Residential	Water Heat	Thermostatic Shower Restriction Valve
98	Residential	Water Heat	Insulating Tank Wrap on Water Heater
120	Residential	Interior Lighting	Electroluminescent Nightlight
121	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Screw-In, 9 W
122	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Screw-In, 14 W
123	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Screw-In, 19 W
124	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Screw-In, 24 W
125	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Screw-In, 40 W
126	Residential	Interior Lighting	ENERGY STAR Qualified LED, Screw-In, 18 W
127	Residential	Interior Lighting	ENERGY STAR Qualified LED, Screw-In, 25 W
128	Residential	Interior Lighting	ENERGY STAR Qualified LED, Screw-In, 6 W
129	Residential	Interior Lighting	ENERGY STAR Qualified LED, Screw-In, 10 W
132	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Light Fixture, 1 or 2 Sockets
134	Residential	Interior Lighting	ENERGY STAR Qualified LED, Light Fixture, 1 or 2 Sockets
135	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Light Fixture, 3 or More Sockets
138	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Recessed Lighting
139	Residential	Interior Lighting	ENERGY STAR Qualified LED, Recessed Lighting
157	Residential	Interior Lighting	ENERGY STAR Qualified CFL, Dimmable, 19 W
185	Residential	Exterior Lighting	Outdoor Lighting Timer

#	Sector	End Use	Measure
186	Residential	Exterior Lighting	Outdoor Motion Sensor
187	Residential	Miscellaneous	Dual Speed Pump Motors
193	Residential	Miscellaneous	Heavy Duty Plug-In Timer
201	Residential	Plug Load	ENERGY STAR® Air Purifier
208	Residential	Plug Load	ENERGY STAR Printer
211	Residential	Plug Load	ENERGY STAR Desktop Computer
214	Residential	Plug Load	ENERGY STAR Game Console
219	Residential	Plug Load	ENERGY STAR Water Cooler
269	Residential	HVAC Aux	Green Fan
321	Residential	Central Heat	Furnace Whistle
338	Residential	HVAC Aux	Programmable Thermostat
360	Residential	HVAC Aux	Duct Sealing
366	Residential	Central Heat	ENERGY STAR ASHP from Electric Furnace and SS AC- 16 SEER and 9.0 hspf
369	Residential	Central Heat	ENERGY STAR GSHP 17.1 EER, 3.6 COP- with desuperheater from Elect Furn and CAC
386	Residential	HVAC Aux	Smart Thermostat
397	Residential	HVAC Aux	Window Shade Film
401	Residential	HVAC Aux	Energy Star Windows
Commercial			
7	Commercial	Miscellaneous	Compressed Air Optimization
8	Commercial	Miscellaneous	High Efficiency Air Compressor
41	Commercial	HVAC Aux	Solid State Cooking Hood Controls
43	Commercial	Cooking	ENERGY STAR Steamer
44	Commercial	Cooking	ENERGY STAR Combination Oven
47	Commercial	Cooking	ENERGY STAR Griddle
58	Commercial	Cooling Chillers	Chilled Water Reset
67	Commercial	Cooling Chillers	Two-Speed Fan Motor on Cooling Tower
69	Commercial	Cooling Chillers	Decrease Cooling Tower Approach Temperature
72	Commercial	Cooling Chillers	MB Air Cooled Chiller - All Compressor Types - 150 Tons
117	Commercial	Cooling DX	HE DX more than 63.33 Tons Other Heat
125	Commercial	HVAC Aux	Reflective Roof Treatment
129	Commercial	HVAC Aux	Canned Lighting Air Tight Sealing
135	Commercial	HVAC Aux	Duct Insulation
153	Commercial	HVAC Aux	Wall Insulation R30
155	Commercial	HVAC Aux	Wall Insulation R38
158	Commercial	HVAC Aux	Duct Location
159	Commercial	HVAC Aux	Duct Sealing

#	Sector	End Use	Measure
160	Commercial	HVAC Aux	Automatic Blinds
166	Commercial	Space Heat	Air Source Heat Pump 5 Tons, 14 SEER, 8.5 HSPF
189	Commercial	Space Heat	Notched V Belts for HVAC Systems
192	Commercial	Space Heat	Water Source Heat Pump 4 Tons, 16 EER
199	Commercial	Water Heat	Faucet Aerators
206	Commercial	Water Heat	Heat Pump Water Heater
215	Commercial	Water Heat	Hot Water Pipe Insulation
218	Commercial	Water Heat	Insulating Tank Wrap on Water Heater
221	Commercial	Water Heat	Low-Flow Showerhead
234	Commercial	Water Heat	VFD on Hot Water Pump
250	Commercial	HVAC Aux	Demand Controlled Ventilation
253	Commercial	HVAC Aux	ECM for Heat Pump (Cooling and Heating)
254	Commercial	HVAC Aux	ECM for VAV Units
258	Commercial	HVAC Aux	Energy Efficient Laboratory Fume Hood
261	Commercial	HVAC Aux	VFD on Kitchen Exhaust Fan
262	Commercial	HVAC Aux	VFD on Chilled Water Pumps
263	Commercial	HVAC Aux	VFD on Condenser Water Pump
264	Commercial	HVAC Aux	VFD on HVAC Fan
268	Commercial	Exterior Lighting	Green LED Traffic Light
269	Commercial	Exterior Lighting	Hand-Man Crosswalk Sign
270	Commercial	Exterior Lighting	Incandescent to HID(Outdoor)
271	Commercial	Exterior Lighting	Induction Street Lighting
280	Commercial	Exterior Lighting	LED Exterior Area Lights - LED fixture (200W)
286	Commercial	Exterior Lighting	Red LED Traffic Light
297	Commercial	Lighting	Cold Cathode Screw-In Bulb
303	Commercial	Lighting	ENERGY STAR® LED Lamp, All Shapes and Directions
329	Commercial	Linear Lighting	2x4 LED Troffer
341	Commercial	Lighting	LED Recessed Downlight
356	Commercial	Linear Lighting	Occupancy Sensors, Switch Mounted
362	Commercial	Linear Lighting	Reduced Wattage (25W) T8 Fixture
372	Commercial	Linear Lighting	Reduced Wattage (28W) T8 Relamping
375	Commercial	Linear Lighting	Standard Wattage (28W) T5 Fixture
412	Commercial	Lighting	High Performance LED High Bay Fixture
415	Commercial	Lighting	High Performance Medium Bay T8 Fixture
433	Commercial	Lighting	Metal Halide Direct Lamp Replacement Install 320W Pulse Start MH Lamp and Ballast
434	Commercial	Lighting	Ceramic Metal Halide Lamp
440	Commercial	Lighting	T5 Medium and High Bay Fixture

#	Sector	End Use	Measure
443	Commercial	Lighting	Auto Off Time Switch
445	Commercial	Linear Lighting	Central Lighting Control System
446	Commercial	Lighting	Time Clock Control
447	Commercial	HVAC Aux	Downsizing Motor During Retrofit
448	Commercial	Miscellaneous	Escalator Motor Controller
455	Commercial	HVAC Aux	Motor Rewind
509	Commercial	HVAC Aux	Pump Impeller Trimming
511	Commercial	HVAC Aux	Synchronous Belt on 15HP Motor
512	Commercial	HVAC Aux	Synchronous Belt on 150HP Motor
514	Commercial	HVAC Aux	Synchronous Belt on 75 HP Motor
577	Commercial	HVAC Aux	VFD on 15HP Open Drip-Proof(ODP) Motor
578	Commercial	HVAC Aux	VFD on 150HP Open Drip-Proof(ODP) Motor
581	Commercial	HVAC Aux	VFD on 75HP Open Drip-Proof(ODP) Motor
595	Commercial	Plug Load	Beverage Vending Machine Controls
638	Commercial	Plug Load	ENERGY STAR® Vending Machine
639	Commercial	Plug Load	ENERGY STAR Water Coolers
649	Commercial	Refrigeration	Anti-Sweat Heater Controls (Cooler)
650	Commercial	Refrigeration	Anti-Sweat Heater Controls (Freezer)
660	Commercial	Refrigeration	SP to ECM Evaporator Fan Motor (Walk-In, Freezer)
662	Commercial	Refrigeration	SP to ECM Evaporator Fan Motor (Walk-In, Refrigerator)
669	Commercial	Refrigeration	Efficient Compressor Motor
672	Commercial	Refrigeration	ENERGY STAR Glass-Door Freezer
695	Commercial	Refrigeration	Heated High R-Value Glass Doors on Display Cases
703	Commercial	Refrigeration	No Heat High R-Value Glass Doors on Display Cases
705	Commercial	Refrigeration	PSC to ECM Evaporator Fan Motor (Reach-In)
706	Commercial	Refrigeration	SP to ECM Evaporator Fan Motor (Reach-In)
707	Commercial	Refrigeration	SP to PSC Evaporator Fan Motor (Reach-In)
711	Commercial	Refrigeration	Refrigeration Commissioning
719	Commercial	Refrigeration	Suction Pipe Insulation (Freezer)
720	Commercial	Refrigeration	Suction Pipe Insulation (Cooler)
723	Commercial	Refrigeration	VSD Controlled Compressor
727	Commercial	Miscellaneous	VFD on Air Compressor
739	Commercial	Miscellaneous	VFD on Conveyor
Industrial			
108	Industrial	HVAC	Synchronous Belt on 15 HP Motor
114	Industrial	HVAC	Synchronous Belt on 200 HP Motor
120	Industrial	HVAC	Synchronous Belt on 40 HP Motor

#	Sector	End Use	Measure
124	Industrial	Motors Other	VFD on 15HP ODP Motor
130	Industrial	Motors Other	VFD on 200HP ODP Motor
136	Industrial	Motors Other	VFD on 40HP ODP Motor
140	Industrial	Lighting	Occupancy Sensors, Switch Mounted
141	Industrial	Lighting	Occupancy Sensors, Ceiling Mounted
171	Industrial	Lighting	Reduced Wattage (28W) T8 Fixture
176	Industrial	Lighting	ENERGY STAR® LED Lamp, All Shapes and Directions
180	Industrial	Lighting	LED Exterior Area Lights
186	Industrial	Lighting	LED Recessed Downlight
199	Industrial	Lighting	Reduced Wattage (25W) T8 Fixture
205	Industrial	Lighting	High Performance Medium Bay T8 Fixture
208	Industrial	Lighting	Standard Wattage (28W) T5 Fixture
212	Industrial	Lighting	T5 Medium and High Bay Fixture
258	Industrial	Process Specific	Block Heater Timer
286	Industrial	HVAC	Ceiling Insulation R60
295	Industrial	HVAC	Wall Insulation R30
304	Industrial	HVAC	HE Ventilation Fan
305	Industrial	HVAC	Direct Drive Motor
309	Industrial	Motors Pumps	Motor Rewind 101-200HP
310	Industrial	Motors Pumps	Motor Rewind 201-500HP
311	Industrial	Motors Pumps	Motor Rewind 20-50HP
312	Industrial	Motors Pumps	Motor Rewind 500HP+
313	Industrial	Motors Pumps	Motor Rewind 51-100HP
314	Industrial	Motors Other	Material Handling
316	Industrial	Motors Other	Paper - Large Material Handling
317	Industrial	Motors Other	Paper - Material Handling
318	Industrial	Motors Other	Paper - Premium Control Large Material
331	Industrial	Motors Pumps	Grain Bin Aeration Control System
334	Industrial	Compressed Air	Efficient Air Compressor
339	Industrial	Compressed Air	Low Pressure-drop Filters
341	Industrial	Compressed Air	Receiver Capacity Addition
370	Industrial	Process Specific	Paper - Efficient Pulp Screen
371	Industrial	Process Cooling	VSD Controlled Compressor
374	Industrial	Process Cooling	Cold Storage Tune-up
384	Industrial	Motors Other	Cogged Belt on 15HP ODP Motor
387	Industrial	Motors Other	Cogged Belt on 40HP ODP Motor
415	Industrial	Compressed Air	Compressed Air Storage Tank

#	Sector	End Use	Measure
416	Industrial	Process Cooling	Process Cooling Ventilation Reduction
417	Industrial	Process Specific	High Efficiency Welder
418	Industrial	Other	3-phase High Frequency Battery Charger - 1 shift
419	Industrial	Other	3-phase High Frequency Battery Charger - 2 shifts
420	Industrial	Other	3-phase High Frequency Battery Charger - 3 shifts
422	Industrial	Process Cooling	Automatic High Speed Doors - between freezer and dock
438	Industrial	Lighting	Auto Off Time Switch
439	Industrial	Lighting	Central Lighting Control System
442	Industrial	Lighting	Time Clock Control
446	Industrial	Compressed Air	VFD on Air Compressor

Appendix B Top Measures by Savings Potential

Table B-1: Top 10 Residential Measures by Sum of Annual Incremental Economic Savings Potential (TRC)

Rank	Measure Name	Economic Potential (kWh)	Savings Contribution
1	Programmable Thermostat	43,555,318	18.33%
2	ENERGY STAR® Qualified CFL, screw-in	28,041,744	11.8%
3	ENERGY STAR Desktop Computer	24,423,187	10.28%
4	Smart Thermostat	19,017,807	8.00%
5	ENERGY STAR Clothes Washer	17,966,846	7.56%
6	ENERGY STAR Qualified LED, screw-in	17,782,431	7.5%
7	Outdoor Lighting Timer	15,553,442	6.55%
8	ENERGY STAR Clothes Dryer	13,885,179	5.84%
9	ENERGY STAR Qualified CFL, Recessed Lighting	9,959,108	4.19%
10	Duct Sealing	8,909,788	3.75%
	TOTAL	199,094,851	83.4%

Table B-2: Top 10 Commercial Measures by Sum of Annual Incremental Economic Savings Potential (TRC)

Rank	Measure Name	Economic Potential (kWh)	Savings Contribution
1	Standard Wattage (28W) T5 Fixture	98,025,384.5	18.8%
2	Anti-Sweat Controls and High R-Value Glass Doors	83,779,091.3	16.1%
3	ENERGY STAR LED Lamp, All Shapes and Directions	58,587,573.3	11.3%
4	SP to ECM or PSC Evaporator Fan Motor	50,557,522.1	9.7%
5	Reduced Wattage (25W) T8 Fixture	28,393,712.4	5.5%
6	VFD on Motor, Compressor, or Pump	19,317,140.4	3.7%
7	Synchronous Belt on Motor	16,281,095.7	3.1%
8	Occupancy Sensors, Switch Mounted	13,086,448.1	2.5%
9	Efficient Compressor Motor	12,964,682.6	2.5%
10	High Performance LED High Bay Fixture	10,884,858.9	2.1%
	TOTAL	391,877,509	75.3%

Table B-3: Top Industrial Measures by Sum of Annual Incremental Economic Savings Potential (TRC)

Rank	Measure Name	Economic Potential (kWh)	Savings Contribution
1	Reduced Wattage (28W) T8 Fixture	17,424,126.8	18.6%
2	Reduced Wattage (25W) T8 Fixture	14,254,148.4	15.2%
3	Direct Drive Motor	13,811,084.9	14.7%
4	VFD on ODP Motor	13,336,648.4	14.2%
5	LED Exterior Area Lights	10,853,538.1	11.6%
6	Synchronous Belt on Motor	5,832,254.2	6.2%
7	Auto Off Time Switch	4,234,876.1	4.5%
8	Ceiling Insulation R60	2,528,830.7	2.7%
9	3-phase High Frequency Battery Charger	2,264,746.5	2.4%
10	High Performance Medium Bay T8 Fixture	1,377,193.0	1.5%
	TOTAL	85,917,447	91.7%

Appendix C Alternative Avoided Energy Cost Achievable Potential Scenarios

Table C-1: 20 year levelized avoided energy cost of $0.06/kWh

	Baseline Sales - 2034	Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
		Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales
Res	2,961,147,696	134,506,926	4.5%	181,352,773	6.1%	220,686,977	7.5%
Com	3,425,163,076	389,972,496	11.4%	503,779,368	14.7%	585,463,555	17.1%
Ind	1,006,514,739	73,428,631	7.3%	88,967,262	8.8%	95,560,487	9.5%
Total	7,392,825,511	597,908,053	8.1%	774,099,403	10.5%	901,711,019	12.2%

Table C-2: 20 year levelized avoided energy cost of $0.08/kWh

	Baseline Sales - 2034	Ach. Low (33%)		Ach. Mid (50%)		Ach. High (75%)	
		Savings Potential	% of Sales	Savings Potential	% of Sales	Savings Potential	% of Sales
Res	2,961,147,696	180,739,986	6.1%	244,190,927	8.2%	290,552,046	9.8%
Com	3,425,163,076	518,007,798	15.1%	678,360,767	19.8%	775,780,752	22.6%
Ind	1,006,514,739	77,364,019	7.7%	93,411,250	9.3%	100,284,483	10.0%
Total	7,392,825,511	776,111,804	10.5%	1,015,962,944	13.7%	1,166,617,280	15.8%

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